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## (54) IMPROVED BATTERY CONSTRUCTION

(71) We, DUNLOP AUSTRALIA LIMITED, of 108 Flinders Street, Melbourne, in the State of Victoria, Australia, a Company incorporated under the Victorian Companies

5 Act 1938, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 This invention relates to a multi-cell battery such as a lead acid battery.

One of the major disadvantages of current constructions of lead batteries is the high weight and cost of the cell plates formed of a lead alloy grid pasted with active battery material. Also because of the low mechanical strength of the lead alloys used in grids, the section of the alloys elements of the grid must be relatively large, and hence the completed battery is bulky in addition to heavy and costly.

The manufacture of conventional lead acid batteries and similar multi-cell batteries is also costly as a result of the number of separate operations involved, including the manufacture of the individual grids, the pasting of the individual grids, the assembly of the grids of differing polarity and separator members to form each cell, the assembly of the cells to a pre-formed battery case, forming the electrical connections between the cells in the case, and finally closing the case with a lid or the like. Furthermore the formation of an effective durable connection between the plates within each cell, and between assemblies of plates in adjoining cells is difficult to achieve under conditions of high volume production. The current trend is to make the connection between adjoining cells through an opening in the cell wall, but this has produced problems in achieving a durable seal between the connecting member and the cell wall.

In our Patent Specification No. 1,430,205 there is proposed a multi-cell battery construction comprising a plurality of frames formed of a suitable mouldable material with each frame defining a plurality of active material support areas arranged in side by side relationship across the width of the frame. After the support areas in each frame have

been pasted with active material so that adjacent support areas in each frame are of opposite polarity, a number of such frames are assembled side by side in the direction normal to the width of the frames. The pasting of the frame is also arranged so that when the frames are assembled side by side adjacent areas in adjoining frames are of opposite polarity. The support areas in each frame are formed by division portions moulded as an integral part of the frame. The division portions in adjacent frames are secured together in sealed relation to form, in the finished assembly of frames, partitions between adjacent cells of the battery.

As is customary in batteries employing a liquid electrolyte, separator members of a porous material are required between adjoining plates of opposite polarity. The battery disclosed in the above-mentioned specification includes strips of conventional separator material which are located between the areas of active battery material of opposite polarity in adjacent frames as the frames are assembled in the side by side relationship. However in the above-mentioned specification no particular provision is made to facilitate simple and fast assembly of the separator strips or arcuate location thereof with respect to the frames.

It is the object of the present invention to provide a battery construction which will further simplify the manufacture and at least reduce many of the problems of production and disadvantages in construction of presently known multi-cell batteries.

With this object in view there is provided a multi-cell battery including a plurality of frames formed of a material as herein specified, each frame defining a plurality of separate material receiving areas arranged in side by side relationship across the width of the frame, each frame including portions forming divisions between adjacent support areas of the frame, the frames being arranged in a side by side relationship in a direction normal to the width of the frame with the portions of each frame forming the divisions between adjacent receiving areas secured in a sealed relationship to the corresponding portions in adjacent frames to form partitions between

adjacent cells of the battery, individual masses of active battery material supported in each area of each frame so that each area forms a plate of the battery, the active battery material in respective areas being selected so that adjacent areas in each frame form plates of opposite polarity and adjacent areas in adjoining frames form plates of opposite polarity, and electrolyte porous separator member interposed between areas of active material of opposite polarity in adjoining frame, said separator members being supported and positively located in said interposed position by co-operation with at least one of the adjoining frames.

There is also provided a multi-cell battery including a plurality of frames formed of a material as herein specified, each frame defining a plurality of material support areas arranged in side by side relationship across the width of the frame, the frames being arranged in a side by side relationship in a direction normal to the width of the frame with the portions of each frame forming the divisions between adjacent support areas secured in a sealed relationship to the corresponding portions in adjacent frames to form

adjacent cells of the battery, each alternate frame having an electrolyte porous separator member spanning each support area thereof and sealed to the portions of the frame defining said support area, and individual masses of active battery material supported in each support area of the remaining frames so that each said area forms a plate of the battery, the active battery material in respective areas being selected so that adjacent areas in each frame form plates of opposite polarity and adjacent areas on opposite sides of each separator member form plates of opposite polarity.

The frames of the battery are formed from a mouldable material which is electrically insulating at the intended operating voltage of the battery, and is inert to the active materials of the battery and any material produced during operation of the battery; herein referred to as "material as herein specified". Suitable thermoplastic material for use in the construction of frames are high impact polystyrene, ABS, and polypropylene.

Conveniently each frame is of rectangular form having a continuous perimeter member and a number of division portions parallel to two opposite sides of the frame to define the plurality of support areas. The perimeter member and division portions of adjacent frames interfit and are sealed together, so that the perimeter member forms two opposite walls, a top, and a bottom of the battery and the division portions form the plurality of cell partitions of the battery. The adjacent frames may be arranged so that the frames are secured together by ultra-sonic weld which will also provide the required seal

between the perimeter member and division portion of adjacent frames.

There is thus provided a plurality of side by side column-like spaces in the frame to receive active material or separator material. Each column-like space may be divided into smaller areas by a plurality of transverse elements of lesser thickness than the division portions to provide additional support, which which may be particularly desirable for the areas which receive active material.

The frames which support the separator material may be over-all thicker than the frames supporting active material, and as the separator material is conveniently made of thin sheet material, the thicker frames provide a greater electrolyte capacity. The frame may be moulded in situ about the separator material so that the margin of the latter is embedded in the frame.

Electrically conductive elements may be embedded in the members of the frame during formation thereof and extend into the area which receives the active material to provide electrical collectors, for the active material, and if desired, the electrical connection between areas of negative and positive active material.

If frames carrying separator material are not used, and all of the frames are pasted with active material and assembled side by side, an individual separator member of porous material is inserted between the positive and negative paste in adjoining frames.

A battery formed by an assembly of frames as previously described has a number of cells determined by the number of active material areas in each frame. The adjacent active material areas in each two adjacent frames being of opposite polarity form a basic cell having a nominal voltage of 2 volts in the case of a lead acid cell. Thus the voltage and capacity of the battery is determined by the number of active material areas in each frame and the number of frames carrying active material in the assembly, respectively.

Although it is possible to electrically connect the basic cells in any desired arrangement, this construction of battery is highly suitable for connecting the basic cells formed by two adjoining frames in series, and connecting the terminals of the frames in parallel. When this arrangement of cell connections is used, suitable connector members may be located in the frame during moulding thereof to electrically interconnect the cells in the finished assembly of frames. If the basic cells formed by two frames carrying active material are to be connected in series, an intercell connector member is provided in each alternate division portion of the frame, with the intercell connector members in each frame staggered with respect to the connector members in the adjacent frame.

Also terminal elements may be located in

the sides of the frame forming moulding, the location and number of terminal elements being determined by the number of active material areas in the frame. If there are an even number of paste areas in each frame there is provided a terminal element at each end of each alternate frame. Where there are an odd number of paste areas in each frame there is a terminal element at alternate ends of adjacent frames. The terminal elements of individual frames are interconnected by welding to a connector strap or by other convenient means, and the battery main terminals are suitably connected thereto.

As previously indicated, the perimeter of the frames and the division portions are sealed together, with or without the provision of interfitting elements on adjacent frames so that the assembly of frames form the top, bottom, two opposite walls, and cell partitions of the battery case. The battery case is then completed by bonding cover plates to the exposed face of the two end frames of the assembly. Also suitable covers are provided if the frames have terminal elements projecting from the sides of the frames coupled by a connector strap.

Some of the advantages of the battery constructed in accordance with the present proposal are:

1. The reduction of battery weight and size by elimination of bulky lead alloy grids;
2. Elimination of forming intercell connections during assembly, with the avoidance of consequent sealing problems;
3. The possibility to eliminate a separate battery case;
4. Additional support for active material to eliminate shedding of active material.
5. Increased capacity per unit weight of battery.

The invention will be more readily understood from the following description of one practical arrangement of the invention with reference to the accompanying drawings wherein:

Figure 1 is a general perspective view, partly in section, of a battery incorporating one embodiment of the present invention;

Figure 2 is a side elevation of one grid assembly suitable for use in a battery shown in Figure 1;

Figure 3 is an enlarged cross-sectional view along the line 3—3 in Figure 2;

Figure 4 is an enlarged sectional view along the line 4—4 in Figure 2;

Figure 5 is a plane view of an assembly of grids as shown in Figure 2; and

Figure 6 is a partial sectional view of an alternative construction to that shown in Figure 3.

Referring now to the drawings, the battery 10 comprises a housing 11 enclosing an assembly of frame members 12 arranged and bonded together so as to form a plurality of

cells 14 separated one the other by a partition wall 13 composed of the abutting vertical elements of the respective frame members 12.

Referring now to Figure 2, each frame member 12 comprises a perimeter member 15 having top and bottom elements 16 and 17 and opposite side elements 18 and 19. Extending between the top and bottom elements 16 and 17 are division elements 20 which are parallel to the side elements 18 and 19. The frame and the vertical division elements together define three column-like areas 22, 23 and 24 which will, in the finished battery, be pasted with appropriate active battery material.

The top and bottom elements and the side and division elements are provided on one face with a continuous tongue 27 at right angles to the general plane of the frame, and on the opposite face a continuous groove 28, so that when a plurality of frames are assembled in side by side relationship as shown in Figures 3, and 3, the tongue on one frame interfits with the groove on the adjacent frame. Each frame is provided with a shoulder adjacent the groove 28 and tongue 27, which bounds the areas which will support the active battery material. When the frames are assembled in a side by side relationship the shoulders 48 in adjacent frames form a recess 49. The recess 49 provides a positive location for the strips 32 of separator material during assembly, and the edges of the separator strips 32 are gripped therein in the finished assembly of frames. The interfitting tongue and groove are adhered or otherwise secured together, with or without the use of additional sealing compound, so that the connection between the top and bottom elements, the side elements and division elements in respective adjacent frames will not permit the leakage of electrolyte between the cells in the finished battery. The frames may be secured together by the use of suitable adhesives or solvents applied to the interfitting tongues and grooves. Ultra-sonic welding may also be used to secure and seal the frames together. The adhesive or solvent may be selected, or the welding performed in a manner, so that there is also a degree of adhesion or fusion achieved between the edges of the separator strips and the frame during the assembly and securing of the frames in the side by side relationship. An assembly of a plurality of frames of this construction provides an open ended box-like structure with internal partitions, the sides and top and bottom of the box being formed by the interfitting side, top and bottom elements of the frame and the partitions being formed by the interfitting division elements.

The frames also include a plurality of vertically spaced support elements 30 extending between the opposite side elements 18, 19

and integral with the division elements 20. In the frame shown in Figure 2 there are three support elements 30, and these elements are of a thickness less than the thickness of the side and vision elements so that when a number of frames are assembled in a side by side relationship, the support elements 30 in adjacent frames are spaced one from the other. The support elements 30 divide the area between the respective division elements 20 so that the material subsequently located between the division elements is given additional support and will not become dislodged during service.

In the preferred form, grid-like structures 26, 26a are provided to span part or all of the area between the respective division elements to provide even further support for the active battery material in those areas which form active material areas in the finished battery. The grids may be formed of the same material as the remainder of the frame and moulded as an integral part thereof, but preferably are made of an electrically conductive material which is not adversely effected by the materials of the battery, such as lead alloy, and are embedded in the elements of the frame during the moulding of the frame.

In the embodiment shown in Figure 2 the grid 26 extends through the side element 18 of the frame and is embedded in, but does not extend through the adjacent division element 20. The portion of the grid 26 external of the frame provides a terminal for electrically connecting the cells constituted by an assembly of frames. The grid 26a extends through the other division element 20a and is embedded in but does not extend through the side element 19. The grid 26a thus forms an intercell connector between plates 23 and 24. The grids 26 and 26a thus provide support for the active battery material, act as a current collector for the respective plates, and form intercell connectors and/or terminals as required in respect of cells formed by the assembly of frames.

During the pasting of the frames the area above the upper support element 30 in each frame is not pasted so that when the frames are assembled together electrolyte reservoirs 31 are formed as shown in Figure 1. Also during assembly, separator strips 32 are inserted between the plates of active material in adjacent frames. The separators perform their normal function in a battery, and are made of conventional material.

In an alternative construction, as illustrated in Figure 6, a frame 45 carrying a separator member 46 in each support area is positioned between the frames described above carrying the active battery material. The frame 45 carrying the separator member 46 is of the same general construction as that carrying the active battery material, but is

preferably thicker. The separator member 46, preferably made of sheet material, is sealed about the perimeter to the perimeter member 15 and to the division elements 20 of the frame. All separator members in a single frame may be formed from a single sheet of suitable material with the frame moulded in situ on to the sheet. By suitable selection of the materials of the frame and separator the separator material is rendered non-porous where it is embedded in the division elements 20 of the frame to prevent leakage of electrolyte between adjoining cells of the finished battery via the common separator sheet. The separator may be formed of a material which will fuse under heat so that during moulding the portion of the sheet contacted by the hot frame material is fused to render it non-porous.

In order to assist the gas, generated when the battery is in use, to escape from between the plates, vent strips 33 made of porous material extend vertically through the mass of active material forming each plate. The vent strip may be added to the frame prior to or during the pasting operation, or may be located in the mould during moulding of the frame so that the vent is bonded to the support elements 30.

In order to form a battery such as is shown in Figure 1, a plurality of frames of the construction shown in Figure 2 are individually pasted with conventional active battery material so that the adjacent areas in each frame are of opposite polarity. Thus each frame forms a plurality of side by side plates of alternate positive and negative polarity. A number of these frames are then assembled together in a side by side relationship with each plate in each frame, adjacent a plate of opposite polarity in the adjoining frame. In assembling the frames, the tongues and grooves on adjacent frames interfit and are sealed together. The series of cells so formed by each two adjacent frames are electrically connected in series by the grids, such as 26a, and have positive and negative terminal tags 37 at respective ends as seen in Figure 5. The terminal tags 37 at opposite ends of the assembly of frames are then connected to a respective connector straps 35 which carry the main terminals such as 36.

Although the assembly of frames will form a top, bottom and two opposite side walls, the remaining two sides include exposed active material and the two side plates 38 are secured to these two sides to complete the battery case. In some applications it is also desirable to provide cover plates 39 for the terminal tags and connector straps, and these cover plates may be secured to the side plates 38. The cover 40 is also provided with openings 41 which align with openings 42 which have been cut into the top face of the assem-

bly of frames, to enable the introduction of electrolyte to each cell of the battery.

It will be appreciated that by suitable adaption of the construction of the frames, the cover plates and/or top cover may not be required.

#### WHAT WE CLAIM IS:—

1. A multi-cell battery including a plurality of frames of a mouldable material which is electrically insulating at the intended operating voltage of the battery and is inert to the active materials of the battery and any material produced during operating of the battery, each frame defining a plurality of separate material receiving areas arranged in side by side relationship across the width of the frame, each frame including portions forming divisions between adjacent support areas of the frame, the frames being arranged in a side by side relationship in a direction normal to the width of the frame with the portions of each frame forming the divisions between adjacent receiving areas secured in a sealed relationship to the corresponding portions in adjacent frames to form partitions between adjacent cells of the battery, individual masses of active battery material supported in each area of each frame so that each area forms a plate of the battery, the active battery material in respective areas being selected so that adjacent areas in each frame form plates of opposite polarity and adjacent areas in adjoining frames form plates of opposite polarity, and electrolyte porous separator member interposed between areas of active material of opposite polarity in adjoining frames, said separator members being supported and positively located in said interposed position by co-operating with at least one of the adjoining frames.

2. A multi-cell battery as claimed in Claim 1, wherein each separator member is sealed to the portions of the frame defining the support area which said separator member spans.

3. A multi-cell battery as claimed in Claim 1, wherein the frames are adapted so that when assembled in said side by side relationship respective recesses are formed by two adjoining frames to receive at least part of the edge portion of each separator member interposed between the said adjoining frames.

4. A multi-cell battery including a plurality of frames formed of a mouldable material which is electrically insulating at the intended operating voltage of the battery and is inert to the active materials of the battery and any material produced during operating of the battery, each frame defining a plurality of separate material receiving areas arranged in side by side relationship across the width of the frame, each frame including portions forming divisions between adjacent support areas of the frame, the

frames being arranged in a side by side relationship in a direction normal to the width of the frame with the portions of each frame forming the divisions between adjacent receiving areas secured in a sealed relationship to the corresponding portions in adjacent frames to form partitions between adjacent cells of the battery, each alternate frame having an electrolyte porous separator member spanning each support area thereof and secured to the portions of the frame defining said support area, and individual masses of active battery material supported in each support area of the remaining frames so that each said area forms a plate of the battery, the active battery material in respective areas being selected so that adjacent areas in each frame form plates of opposite polarity and adjacent areas on opposite sides of each separator member form plates of opposite polarity.

5. A battery as claimed in claim 1, 2, 3 or 4 wherein electric connector members extend through alternate division portions of the frames supporting active battery material the arrangement of the connector members being such that each two adjacent frames supporting active battery material form a series connected battery having a number of cells equal to the number of division portions plus one.

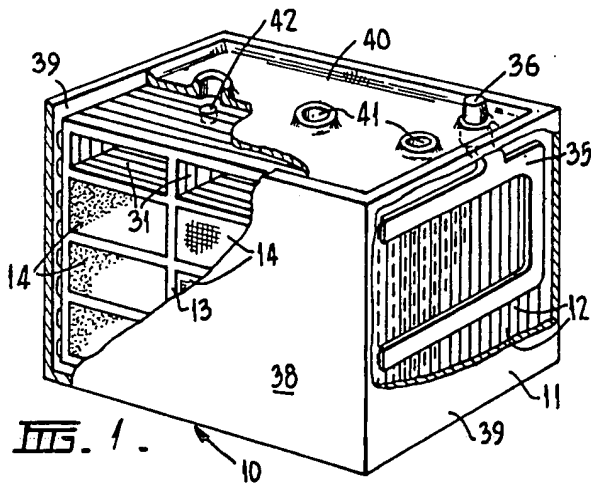
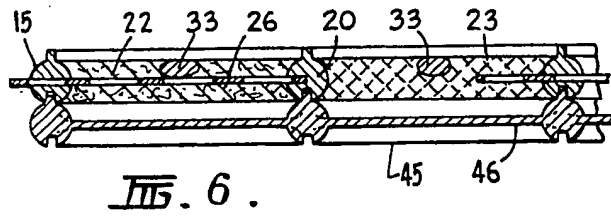
6. A battery as claimed in claim 1, 2, 3 or 4 wherein at least some of the frames supporting active battery material include a terminal member extending from the active battery material of a plate at one side of the frame through said side of the frame, and a connector member extends through each alternate division portion of the frame counted from said one side to electrically connect the plates of opposite polarity separated by said alternate division portions.

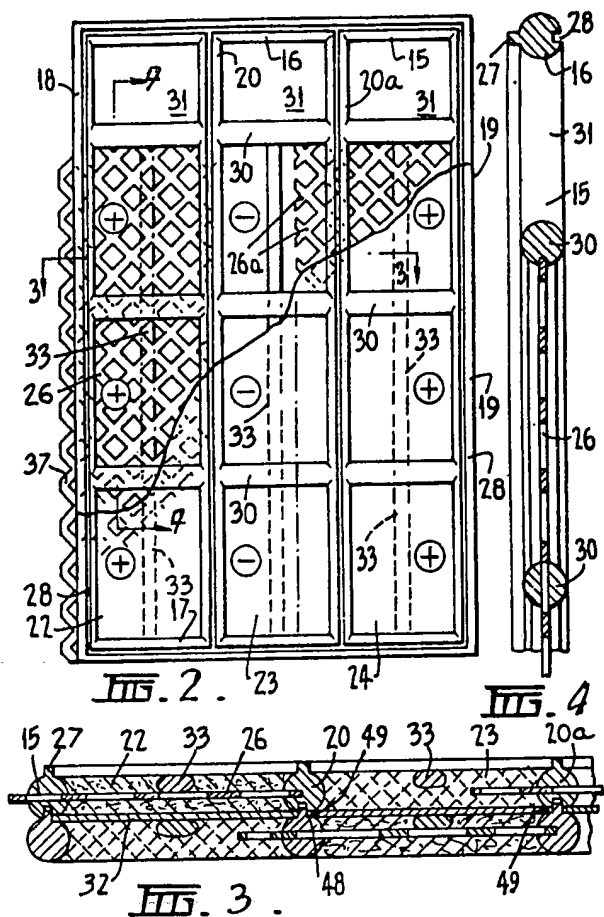
7. A battery as claimed in any one of the preceding claims wherein the frame members are adapted to interfit one with the other when assembled in the side by side relation.

8. A battery as claimed in any one of the preceding claims wherein each division portion of each frame is formed with a laterally projecting tongue on one side and a groove on the opposite side, said tongue and groove extending the full length of the division portion and being arranged so that when the frames are assembled in side by side relation, the tongues on one frame engage the grooves on the adjoining frame.

9. A multi-cell battery substantially as hereinbefore described with reference to and as illustrated by the accompanying drawings.

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